NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

MEETING ANNOUNCEMENT

DATE: **March 31, 2010**

LOCATION: **Orinda Masonic Center, 9 Altarinda Rd., Orinda**

TIME: **6:30 p.m. social; 7:00 p.m. talk (no dinner) Cost: $5 per regular member; $1 per student or K – 12 teachers**

SPEAKER: **Dr. M. C. Erskine,**
Consulting Geologist

Structural Model for the Interpretation of the Central Basin and Range Province of Utah and Nevada

During the Mesozoic, the sedimentary rocks of the miogeocline of western Utah and eastern Nevada thrust eastward over the North American continental margin. During the Cenozoic, this folded and thrusted terrain extended westward, essentially opposite to Mesozoic vergence. The miogeocline consists of Eocambrian to Jurassic paraconformable sedimentary rocks over 12 kilometers (40,000 feet) thick in western Utah and eastern Nevada.

Stratigraphic and structural relief across the twenty mile width of Steptoe Valley, between outcrops of the Jurassic Navajo (Aztec) Sandstone at Curry Junction and outcrops of Eocambrian quartzite north of Cherry Creek, is as much as twelve kilometers. Clasts of Prospect Mountain Quartzite in the basal conglomerate of the Cretaceous (?) to Eocene Sheep Pass Formation indicate at least seven and a half kilometers of exposed stratigraphic relief by early Sheep Pass time.

Systematic regional outcrop patterns include linear antiformal structural culminations cored with Cambrian quartzite and older sedimentary rocks, (Fish Springs/ House/Wah Wah Range; Raft River/Pilot/Goshute/Deep Creek Range/ Snake/Highland Range; Ruby/White Pine/Grant/Quinn Canyon/Groom Range; Toiyabe Range). These anticlinoria are separated by synclinoria of structurally dismembered younger sedimentary rocks (Confusion Range; Buttes Range; Sulphur Springs-Monitor Ranges; Pancake, Pahroc, and others). The synclinoria commonly show clear westward structural vergence on their eastern limb. They preserve miogeoclinal sedimentary rocks as young as Jurassic Navajo Sandstone in their cores (Buttes Range Synclinorium near Curry, Nevada). Outcrops of Cretaceous marine sedimentary rocks are absent. Outcrops of pre-miogeocline crystalline basement are not exposed beneath the thick sections of Eocambrian clastic rocks.

…Continued on the back…

NCGS 2009 – 2010 Calendar

Wednesday March 31, 2010
Structural Model for the Interpretation of the Central Basin and Range Province of Utah and Nevada
Dr. Mel Erskine, Consulting Geologist
7:00 pm at Orinda Masonic Lodge

Wednesday April 28, 2010
Mars Dust and Ice: A voyage to the poles with Mars Reconnaissance Orbiter
Dr. Adrian Brown, SETI Institute
7:00 pm at Orinda Masonic Lodge

Wednesday May 26, 2010
SPECIAL DINNER MEETING!!
The Haitian Earthquake
(Tentative; Carol is still in Haiti)
Dr. Carol Prentice, USGS, Menlo Park
6:00 pm at Orinda Masonic Lodge **(EARLY**)

Wednesday June 30, 2010
TBA
7:00 pm at Orinda Masonic Lodge

Our Usual Summer Break: July – August 2010

Upcoming NCGS Field Trips

April 18 or 25, 2010 ***Mammoth Rocks and the Geology of the Sonoma Coast;*** **E. Breck Parkman,** Senior State Archaeologist, California State Parks, and **Rolfe Erickson**, Emeritus, Sonoma State University

Do you have a place you've wanted to visit for the geology? Let us know. We're definitely interested in ideas. For those suggestions, or for questions regarding, field trips, please contact John Christian at: **jmc62@sbcglobal.net**.

Peninsula Geologic Society

Upcoming meetings

For an updated list of meetings, abstracts, and field trips go to http://www.diggles.com/pgs/. The PGS has also posted guidebooks for downloading, as well as photographs from recent field trips at this web address. Please check the website for current details.

- April 13, 2010, Dave Wagner, California Geological Survey, ***Recent work on the Oak Creek debris flows east of the Sierras***
- May 11, 2010, Julie C. Fosdick, Stanford, Andes research.
- June 1, 2010, Victoria Langenheim, Presidential address

Association of Engineering Geologists San Francisco Section

Upcoming meetings

Meeting locations rotate between San Francisco, the East Bay, and the South Bay. Please check the website for current details:

- April 13, 2010; 6:00pm Student Night
- May 11, 2010, TBA
- June 8, 2010, John Wakabayashi

To download meeting details and registration form go to: http://www.aegsf.org/.

Entry Level Geologist U. S. Bureau of Reclamation, Mid-Pacific Region

Member **Scott Sochar** reports that the U.S. Bureau of Reclamation has an entry level position in geology. Recent and Spring 2010 college graduates are encouraged to apply. The position was recently opened on March 1st and will remain open until it is filled. The position is will be located in Sacramento. A two-page informational flyer is available; please contact Kathy Schulz, HR Specialist at (916) 978-5474 to obtain more information (requirements, salary range, benefits, and etc.)

NSF Press Release 10-035

Revisiting Chicxulub

A broad look at the evidence for a dinosaur-killing impact

March 4, 2010

For decades, scientists have accumulated ever-larger datasets that suggest an enormous space rock crashed into the ocean off the Yucatan Peninsula more than 65 million years ago, resulting in the Cretaceous-Paleogene (K-Pg) extinction.

Recent research, supported in part by the National Science Foundation (NSF), suggested that the impact could have occurred 300,000 years prior to the K-Pg extinction, and that another cause--perhaps

a second impact, or the long-lasting volcanic activity at the Deccan Traps in what is now India--drove numerous plant and animal species to their end.

Now, an interdisciplinary team of 41 scientists from 12 nations, also supported in part by NSF, has prepared a paper to specifically counter the volcanic and dual-impact alternatives, a comprehensive review of the multiple, global lines of evidence linking a single impact near what is now Chicxulub, Mexico, to the timing and breadth of the K-Pg extinction.

Figure 1: An artist's rendering of the moment of impact at the end of the Cretaceous. Credit: Don Davis, NASA

The researchers, led by Peter Schulte of the University of Erlangen-Nuremburg, present their findings in the March 5, 2010, issue of *Science*.

"We felt it important to present the wealth of data now available about the remarkable and exact correlation between the impact in the Yucatan and the extinction event at the K-Pg boundary," said University of Texas geophysicist Sean Gulick, one of the authors on the paper.

One factor that is not in dispute: the end of the Cretaceous 65.5 million years ago was marked by one of the most devastating extinctions our planet has faced. The most famous victims were the dinosaurs (their avian relatives notwithstanding), but the event also saw the loss of all flying reptiles, most marine reptiles, more than half of land plants and insects, and hosts of other terrestrial and marine organisms--50 to 70 percent of all species on Earth

As with all mass extinctions, paleontologists have long asked why so many organisms disappeared so quickly. The cause, or causes, would have to influence a large swath of the planet, on land and sea, and would have to reflect observations in the geological record.

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Figure 2: The K-Pg boundary as exposed along the side of Interstate 25 near Raton Pass in southern Colorado. The obvious white layer is the K-Pg ejecta layer. It contains elevated levels of iridium and shocked mineral grains. Pollen and spores from Cretaceous plants are found immediately below this layer but not above it, a pattern that is seen from the southern United States all the way north to the Arctic Ocean. This direct link between impact ejecta and plant extinction suggests a very strong cause and effect relationship between impact and extinction. Credit: Kirk Johnson, Denver Museum of Nature & Science

As referenced in the new *Science* paper, one of the key arguments for impact is a well-studied clay layer that appears at K-Pg boundary sites across the globe, usually in association with melt-glass remnants, shocked minerals, and other materials generated by impacts. The authors point out that the layer thickness and the abundance of impact materials both increase systematically with proximity to the Chicxulub crater.

Until 1980, none of the K-Pg boundary sites was linked to an impact. It was not until physicist Luis Alvarez and his son, geologist Walter Alvarez, took a closer look at a thin and unusual clay layer at K-Pg boundary sediments in Italy that the researchers realized the source might be extraterrestrial.

Within the layer--which the current paper now references to at least 350 sites around the world--the researchers found high levels of iridium. The heavy element is not normally found in high concentrations at Earth's surface, but it is highly concentrated in undifferentiated solar system material, like asteroids and comets.

Since that initial discovery, further studies by a number of teams--some of which are represented in the *Science* paper--uncovered more impact evidence within the clay, including the spherules of altered melt-glass and impact-shocked minerals.

"This clay layer--with evidence for it being impact in origin--is found at every well-preserved K-Pg boundary site in the world, showing a truly global event," added Gulick.

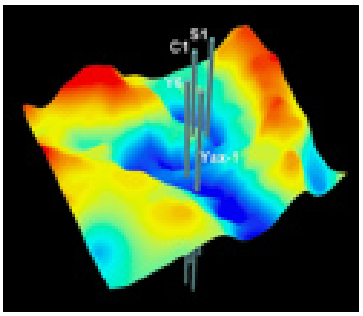

Figure 3: A three-dimensional Bouguer gravity map of the Chicxulub Crater. Petroleum exploration boreholes (C1, S1, and Y6) penetrated the crater structure, which is buried several hundred meters below the surface of the Yucatán Peninsula of Mexico. The Yucatán-6 (Y6) borehole is the discovery hole where Kring and others found shocked quartz and other evidence of impact origin. That discovery prompted the drilling of the Yaxcopoil-1 (Yax-1) borehole, which was the first scientific borehole drilled into the structure by the International Continental Drilling Program (ICDP) in 2001-2002. As described in the current Science *paper, data from that drilling project, when integrated with other K-Pg boundary analyses from around the world, provide a strong link between the Chicxulub impact crater and a mass extinction event 65 million years ago. Proposals to drill into other portions of the immense structure are pending with the ICDP and the Integrated Ocean Drilling Program. Credit: David A. Kring*

Additional studies, both in the field and in laboratory simulations and models, led to a growing consensus in support of the impact hypothesis. As it currently stands, the extinction resulted from the collision of a space rock roughly 10 kilometers in diameter into carbon- and sulfur-rich rocks beneath what is now Chicxulub, Mexico, yielding a crater that is more than 180 kilometers in diameter; regional tsunami, earthquakes and fires; extended (but not total) darkness; cooling temperatures and acid rain.

"The impact event triggered tsunami many times the size of the wave that hit the Indian Ocean on Dec. 26, 2004," said marine geologist Tim Bralower of Penn State University, another of the paper's authors. "These waves caused massive destruction on the sea floor, with the multiple sediment layers representing the deposition of impact-derived material, mixed with sand and silt, by waves and currents over periods of days after the impact. As the energy levels gradually decreased, the materials settling down gradually became finer."

In some sites close to the impact, around the Gulf of Mexico and the Caribbean, there are two spherule-bearing layers, at times separated by sediment a few meters thick, and some of the recent controversy stems from this apparent duality. The lower layer consists of coarser particles including spherules and shocked minerals, and the upper layer consists of finer particles and has a higher iridium content.

"Reports of multiple horizons with elevated iridium concentrations fairly close to the Chicxulub crater have led to a lot of confusion, and suggestions of multiple impacts," said fellow author Greg Ravizza, a marine and environmental geologist at the University of Hawaii at Manoa. "A key point that cannot be ignored is that data from several sites far away from the Chicxulub crater provide no evidence of multiple large impacts. This observation lends very strong support to the careful stratigraphic synthesis in our paper demonstrating the very complex, and frequently disturbed, character of the sections closest to the Chicxulub crater."

The authors close their paper by discussing the speed and scale with which the impact affected living systems, particularly in relation to the speed and scale of volcanic activity.

An impact the size of the Chicxulub event would release large amounts of water, dust and gasses into the atmosphere, temporarily changing climate. While dust alone would not have been able to cause a global winter, tiny carbonate particulates and soot may have amplified the impact's cooling effects.

An estimated 100-500 gigatons of sulfur was also released, contributing to devastating acid rains on land and in the oceans, and producing sunlight-absorbing sulfur aerosols that may have further cooled the Earth for several years.

Because deep ocean temperatures were largely unaffected, the researchers suggest that the climate recovered relatively rapidly. Such a brief transition is in contrast to the centuries-long influx of material into the atmosphere that would result from volcanic activity. Despite the enormity of the Deccan Traps volcanism, sulfur release, for example, might not surpass one half of a gigaton in a year.

At the slower pace of volcanism, organisms would have more time to react, and climatic changes may have approached 2 degrees Celsius of warming, as opposed to cooling.

"The Chicxulub impact was an extremely rapid perturbation of the Earth's ecosystems, at a scale greater than that of any single volcanic event at the time, or of any other impact known since life became prevalent on Earth," added Gulick. "The rate of change and scale of the effects were clearly the cause of the mass extinction at the end of the Cretaceous."

Additionally, the boundary between the end of the Cretaceous and the start of the Paleogene is marked by clear changes in the plants and animals that existed, a change that is not gradual. Species across the globe showed either extinction or major changes in abundance.

Darkness would have severely affected photosynthesis for ocean micro-organisms, eliminating the base for numerous food chains. As a result, the geologic record shows preferential extinction of organisms in food chains relying on plankton as a food source, and preferential survival for organisms in food-chains relying on a foundation of detritus and decayed matter. Many of the organisms that survived were also smaller, indicating survival was dependent on the ability to subsist on limited resources.

"As with the ocean, land-based ecosystems showed the same pattern of greater impact on food chains dependent on live plants," said paleobotanist Kirk Johnson of the Denver Museum of Nature & Science, another author on the paper. "All large, land animals perished. The survivors included groups of animals who either lived in rivers, streams, and lakes or who were small or lived in burrows. Forests were destroyed globally and the earliest Paleogene landscape was covered by ferns, a type of plant that can grow directly from spores--as opposed to conifers and flowering plants that require pollen to interact with a living plant for reproduction."

Across ecosystems, the Paleogene also marks a rapid radiation of new species filling in empty ecological niches, a process that would be unlikely following a more gradual extinction. Such biological evidence, the authors assert, matches best to an impact scenario, corroborating the evidence from the geologic record.

"I think it is likely that Deccan volcanism did have a global effect on Earth's climate, but several hundred thousand years before the end Cretaceous mass extinction," added Ravizza. "Clear evidence demonstrating massive volcanism right at the mass extinction horizon is lacking. While it may be tempting to make this connection, existing data constraining the timing and duration of volcanism just don't support the idea."

According to the authors, no alternative theory yet proposed addresses the global distribution of evidence for the Cretaceous-Paleogene extinction, nor does any other theory clearly present mechanisms that could have led to such abrupt and complete biotic changes.

"The precise correlation of this huge impact crater with a worldwide layer of impact debris--one that lies directly above the extinction level of both marine and land animals and plants--is one of the most phenomenal discoveries in Earth history," said Johnson. "The science is complex, but the story is simple: a single asteroid impact caused global extinctions at the K-Pg boundary."

H. Richard Lane, program director within the Earth Sciences Division at NSF has helped support the work of both research teams. "This ongoing exchange between two groups of scientists has fostered spirited community dialogue around an issue that is riveting to an engaged public," added Lane. "It feeds the appetite of a science-starved audience, and can only benefit science as a whole, while improving the public's understanding of how science progresses."

To view a webcast of Kirk Johnson from the Denver Museum of Nature & Science

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NSF Press Release 10-036

Methane Releases From Arctic Shelf May Be Much Larger and Faster Than Anticipated

Thawing by climate change of subsea layer of permafrost may release stores of underlying, seabed methane

March 4, 2010

A section of the Arctic Ocean seafloor that holds vast stores of frozen methane is showing signs of instability and widespread venting of the powerful greenhouse gas, according to the findings of an international research team led by University of Alaska Fairbanks scientists Natalia Shakhova and Igor Semiletov.

The research results, published in the March 5 edition of the journal Science, show that the permafrost under the East Siberian Arctic Shelf, long thought to be an impermeable barrier sealing in methane, is perforated and is starting to leak large amounts of methane into the atmosphere. Release of even a fraction of the methane stored in the shelf could trigger abrupt climate warming.

"The amount of methane currently coming out of the East Siberian Arctic Shelf is comparable to the amount coming out of the entire world's oceans," said Shakhova, a researcher at UAF's International Arctic Research Center. "Subsea permafrost is losing its ability to be an impermeable cap."

Methane is a greenhouse gas more than 30 times more potent than carbon dioxide. It is released from previously frozen soils in two ways. When the organic material (which contains carbon) stored in permafrost thaws, it begins to decompose and, under anaerobic conditions, gradually releases methane. Methane can also be stored in the seabed as methane gas or methane hydrates and then released as subsea permafrost thaws. These releases can be larger and more abrupt than those that result from decomposition.

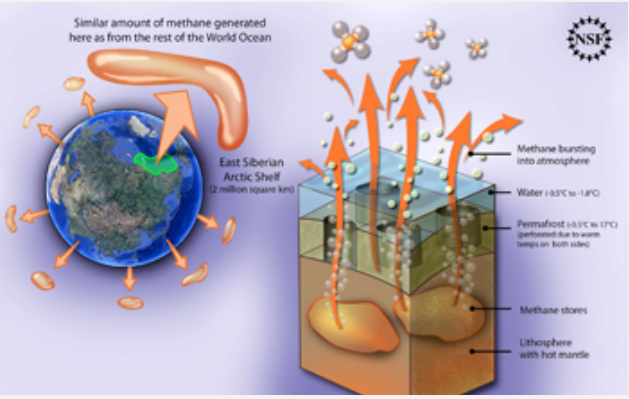


Figure 1: Methane is leaking from the East Siberian Arctic Shelf into the atmosphere at an alarming rate. The permafrost of the East Siberian Arctic Shelf (an area of about 2 million square kilometers) is more porous than previously thought. The ocean on top of it and the heat from the mantle below it warm it and make it perforated like Swiss cheese. This allows methane gas stored under it under pressure to burst into the atmosphere. The amount leaking from this locale is comparable to all the methane from the rest of the world's oceans put together. Methane is a greenhouse gas more than 30 times more potent than carbon dioxide. Credit: Zina Deretsky, National Science Foundation

The East Siberian Arctic Shelf is a methane-rich area that encompasses more than 2 million square kilometers of seafloor in the Arctic Ocean. It is more than three times as large as the nearby Siberian wetlands, which have been considered the primary Northern Hemisphere source of atmospheric methane. Shakhova's research results show that the East Siberian Arctic Shelf is already a significant methane source, releasing 7 teragrams of methane yearly, which is as much as is emitted from the rest of the ocean. A teragram is equal to about 1.1 million tons.

"Our concern is that the subsea permafrost has been showing signs of destabilization already," she said. "If it further destabilizes, the methane emissions may not be teragrams, it would be significantly larger."

Shakhova notes that the Earth's geological record indicates that atmospheric methane concentrations have varied between about .3 to .4 parts per million during cold periods to .6 to .7 parts per million during warm periods. Current average methane concentrations in the Arctic average about 1.85 parts per million, the highest in 400,000 years, she said. Concentrations above the East Siberian Arctic Shelf are even higher.

The East Siberian Arctic Shelf is a relative frontier in methane studies. The shelf is shallow, 50 meters (164 feet) or less in depth, which means it has been alternately submerged or terrestrial, depending on sea levels throughout Earth's history. During the Earth's coldest periods, it is a frozen arctic coastal plain, and does not release methane. As the Earth warms and sea level rises, it is inundated with seawater, which is 12-15 degrees warmer than the average air temperature.

"It was thought that seawater kept the East Siberian Arctic Shelf permafrost frozen," Shakhova said. "Nobody considered this huge area."

"This study is a testament to sustained, careful observations and to international cooperation in research," said Henrietta Edmonds of the National Science Foundation, which partially funded the study. "The Arctic is a difficult place to get to and to work in, but it is important that we do so in order to understand its role in global climate and its response and contribution to ongoing environmental change. It is important to understand the size of the reservoir--the amount of trapped methane that potentially could be released--as well as the processes that have kept it "trapped" and those that control the release. Work like this helps us to understand and document these processes."

Earlier studies in Siberia focused on methane escaping from thawing terrestrial permafrost. Semiletov's work during the 1990s showed, among other things, that the amount of methane being emitted from terrestrial sources decreased at higher latitudes. But those studies stopped at the coast. Starting in the fall of 2003, Shakhova, Semiletov and the rest of their team took the studies offshore. From 2003 through 2008, they took annual research cruises throughout the shelf and sampled seawater at various depths and the air 10 meters above the ocean. In September 2006, they flew a helicopter over the same area, taking air samples at up to 2,000 meters (6,562 feet) in the atmosphere. In April 2007, they conducted a winter expedition on the sea ice.

They found that more than 80 percent of the deep water and more than 50 percent of surface water had

methane levels more than eight times that of normal seawater. In some areas, the saturation levels reached more than 250 times that of background levels in the summer and 1,400 times higher in the winter. They found corresponding results in the air directly above the ocean surface. Methane levels were elevated overall and the seascape was dotted with more than 100 hotspots. This, combined with winter expedition results that found methane gas trapped under and in the sea ice, showed the team that the methane was not only being dissolved in the water, it was bubbling out into the atmosphere.

These findings were further confirmed when Shakhova and her colleagues sampled methane levels at higher elevations. Methane levels throughout the Arctic are usually 8 to 10 percent higher than the global baseline. When they flew over the shelf, they found methane at levels another 5 to 10 percent higher than the already elevated Arctic levels.

The East Siberian Arctic Shelf, in addition to holding large stores of frozen methane, is more of a concern because it is so shallow. In deep water, methane gas oxidizes into carbon dioxide before it reaches the surface. In the shallows of the East Siberian Arctic Shelf, methane simply doesn't have enough time to oxidize, which means more of it escapes into the atmosphere. That, combined with the sheer amount of methane in the region, could add a previously uncalculated variable to climate models.

"The release to the atmosphere of only one percent of the methane assumed to be stored in shallow hydrate deposits might alter the current atmospheric burden of methane up to 3 to 4 times," Shakhova said. "The climatic consequences of this are hard to predict."

Shakhova, Semiletov and collaborators from 12 institutions in five countries plan to continue their studies in the region, tracking the source of the methane emissions and drilling into the seafloor in an effort to estimate how much methane is stored there.

(Shakhova and Semiletov hold joint appointments with the Pacific Oceanological Institute, part of the Far Eastern Branch of the Russian Academy of Sciences. Their collaborators on this paper include Anatoly Salyuk, Vladimir Joussupov and Denis Kosmach, all of the Pacific Oceanological Institute, and Orjan Gustafsson of Stockholm University.)

Dinosaur Had Vibrant Colors, Microscopic Fossil Clues Reveal

ScienceDaily

Deciphering microscopic clues hidden within fossils, scientists have uncovered the vibrant colors that adorned a feathered dinosaur extinct for 150 million years, a Yale University-led research team reported online Feb. 4 in the journal *Science*.

Unlike recently published work from China that inferred the existence of two types of melanin pigments in various species of feathered dinosaurs, the Science study analyzed color-imparting structures called melanosomes from an entire fossil of a single animal, a feat which enabled researchers to reveal rich color patterns of the entire animal.

Figure 1: A water color illustration of Anchiornis huxleyi, an extinct, non-avian dinosaur. (Credit: By Michael DiGiorgio/Courtesy Yale)

In fact, the analysis of melanosomes conducted by Yale team was so precise that the team was able to assign colors to individual feathers of *Anchiornis huxleyi*, a four-winged troodontid dinosaur that lived during the late Jurassic period in China. This dinosaur sported a generally gray body, a reddish-brown, Mohawk-like crest and facial speckles, and white feathers on its wings and legs, with bold black-spangled tips.

"This was no crow or sparrow, but a creature with a very notable plumage," said Richard O. Prum, chair and the William Robertson Coe Professor of Ornithology, Ecology and Evolutionary Biology at Yale and a co-author of the study. "This would be a very striking animal if it was alive today."

The color patterns of the limbs, which strongly resemble those sported by modern day Spangled Hamburg chickens, probably functioned in communication and may have helped the dinosaur to attract mates, suggested Prum.

The transformation of mankind's view of dinosaurs from dull to flamboyant was made possible by a discovery by Yale graduate student Jakob Vinther in the Department of Geology and Geophysics. Vinther was studying the ink sac of an ancient squid and realized that microscopic granular-like features within the fossil were actually melanosomes -- a cellular organelle that contains melanin, a light-absorbing pigment in animals, including birds.

While some scientists thought these granules were remnants of ancient bacteria, Vinther, Prum and Derek E.G. Briggs, the Frederick William Beinecke Professor of Geology and Geophysics and director of the Yale Peabody Museum of Natural History, disagreed. First, they tested Vinther's theory on a 112 million year old feather from Brazil and later inferred the colors of an extinct 47 million-year-old bird.

The latest research team -- which also included scientists from the University of Texas at Austin, University of Akron, Peking University and the Beijing Museum of Natural History -- decided to use the same procedures to closely examine a fossil of *Anchiornis huxleyi*, recently described in Liaoning Province, People's Republic of China. The area has been a gold mine for paleontologists and, among other things, provided abundant evidence confirming a once-controversial theory that modern birds are descendants of theropod dinosaurs.

The Yale team and Julia Clarke, an associate professor of paleontology at the University of Texas at Austin's Jackson School of Geosciences, worked closely with Gao Keqin of Peking University and Li Quanguo and Meng Qingjin of the Beijing Museum of Natural History to select, sample and evaluate the anatomy and feathering of *Anchiornis huxleyi*, important in its own right as a new feathered dinosaur. The team's effort was funded by a special grant from the National Geographic Society and by the National Science Foundation.

The team closely examined 29 feather samples from the dinosaur and did an exhaustive measurement and location of melanosomes within the feathers. The team then did a statistical analysis of how those melanosomes compared to the types of melanosomes known to create particular colors in living birds, using data compiled by Matt Shawkey and colleagues at the University of Akron. The analysis allowed scientists to discern with 90 percent certainty the colors of individual feathers and, therefore, the colorful patterns of an extinct animal.

The research adds significant weight to the idea that dinosaurs first evolved feathers not for flight but for some other purposes.

"This means a color-patterning function -- for example, camouflage or display -- must have had a key role in the early evolution of feathers in dinosaurs, and was just as important as evolving flight or improved aerodynamic function," Clarke said.

The new discoveries provide a wealth of insights into the compelling history of feather evolution in dinosaurs prior to the origin of modern birds. The study documents that color patterning within feathers and among feathers evolved earlier than previously believed. Further, these results indicate dinosaur feathers may have evolved for communication.

"Writing the first scientifically-based 'field guide' description of the appearance of an extinct dinosaur was a exciting and unforgettable experience -- the ultimate dream of every kid who was ever obsessed with dinosaurs," Prum said. "Now that dream is really possible."

Can the Sun and Moon Trigger San Andreas Fault Tremors?

December, 2009; University of California, Berkeley

The faint tug of the sun and moon on the San Andreas Fault stimulates tremors deep underground, suggesting that the rock 15 miles below is lubricated with highly pressurized water that allows the rock to slip with little effort, according to a new study by University of California, Berkeley, seismologists.

Tremors and Minute Stress Changes

"Tremors seem to be extremely sensitive to minute stress changes," said Roland Bürgmann, UC Berkeley professor of earth and planetary science. "Seismic waves from the other side of the planet triggered tremors on the Cascadia subduction zone off the coast of Washington state after the Sumatra earthquake last year, while the Denali earthquake in 2002 triggered tremors on a number of faults in California. Now we also see that tides – the daily lunar and solar tides – very strongly modulate tremors."

Deep Water Under Extreme Pressure

In a paper appearing in the December 24, 2009 issue of the journal Nature, UC Berkeley graduate student Amanda M. Thomas, seismologist Robert Nadeau of the Berkeley Seismological Laboratory and Bürgmann argue that this extreme sensitivity to stress – and specifically to shearing stress along the fault – means that the water deep underground is under extreme pressure.

"The big finding is that there is very high fluid pressure down there, that is, lithostatic pressure, which means

pressure equivalent to the load of all rock above it, 15 to 30 kilometers (10 to 20 miles) of rock," Nadeau said. "Water under very high pressure essentially lubricates the rock, making the fault very weak."

Earth Tides

Though tides raised in the Earth by the sun and moon are not known to trigger earthquakes directly, they can trigger swarms of deep tremors, which could increase the likelihood of quakes on the fault above the tremor zone, the researchers say. At other fault zones, such as at Cascadia, swarms of tremors in the ductile zone deep underground correlate with slip at depth as well as increased stress on the shallower "seismogenic zone," where earthquakes are generated. The situation on the San Andreas Fault is not so clear, however.

"These tremors represent slip along the fault 25 kilometers (15 miles) underground, and this slip should push the fault zone above in a similar pattern," Bürgmann said. "But it seems like it must be very subtle, because we actually don't see a tidal signal in regular earthquakes. Even though the earthquake zone also sees the tidal stress and also feels the added periodic behavior of the tremor below, they don't seem to be very bothered."

Deep Motion on the San Andreas Fault

Nevertheless, said Nadeau, "It is certainly in the realm of reasonable conjecture that tremors are stressing the fault zone above it. The deep San Andreas Fault is moving faster when tremors are more active, presumably stressing the seismogenic zone, loading the fault a little bit faster. And that may have a relationship to stimulating earthquake activity."

Non-Volcanic Tremors

Seismologists were surprised when tremors were first discovered more than seven years ago, since the rock at that depth – for the San Andreas Fault, between 15 and 30 kilometers (10 to 20 miles) underground – is not brittle and subject to fracture, but deformable, like peanut butter. They called them non-volcanic tremors to distinguish them from tremors caused by fluid – water or magma – fracturing and flowing through rock under volcanoes. It was not clear, however, what caused the non-volcanic tremors, which are on the order of a magnitude 1 earthquake.

Looking for Underground Tremors

To learn more about the source of these tremors, UC Berkeley seismologists began looking for tremors five years ago in seismic recordings from the Parkfield segment of the San Andreas Fault obtained from sensitive bore-hole seismometers placed underground as part of the UC Berkeley's High-Resolution Seismic Network. Using eight years of tremor data, Thomas, Bürgmann and Nadeau correlated tremor activity with the effects of the sun and moon on the crust and with the effects of ocean tides, which are driven by the moon.

They found the strongest effect when the pull on the Earth from the sun and moon sheared the fault in the direction it normally breaks. Because the San Andreas Fault is a right-lateral strike-slip fault, the west side of the fault tends to break north-northwestward, dragging Los Angeles closer to San Francisco.

"When shear stress on a plane parallel to the San Andreas Fault most encourages slipping in its normal slip direction is when we see the maximum tremor rate," Bürgmann said. "The stress is many, many orders of magnitude less than the pressure down there, which was really, really surprising. You essentially could push it with your hand and it would move."

Magnitudes of Shear Stress

In fact, the shear stress from the sun, moon and ocean tides amount to around 100 Pascals, or one-thousandth atmospheric pressure, whereas the pressure 25 kilometers underground is on the order of 600 megaPascals, or 6 million times greater.

Nadeau and colleagues reported earlier this year that earthquakes in 2003 and 2004 near the Parkfield segment of the San Andreas Fault increased both tremor activity and stress on the fault itself.

In addition, Nadeau noted, other scientists have shown small tidal effects on tremors in the Cascadia subduction zone, with increased amplitude during certain periods, though they were unable to distinguish between tugs along the fault and tugs across, or normal to, the fault.

The Role of Subsurface Fluids

"We were really able to tighten the nuts down on whether it is a normal-fault stress change or an along-fault stress change that is stimulating the tremor," he said. The fact that tremors are triggered by along-fault shear stress "means that fluids are probably the explanation."

It may be that tremors only occur on faults where fluid is trapped deep underground with no cracks or fractures allowing it to squirt away, Nadeau added. That may explain why tremors are not observed on other faults, despite intense searching.

"There is still all lot to learn about tremor and earthquakes in fault zones," he said. "The fact that we find tremors adjacent to a locked fault, like the one at Parkfield, makes you think there are some more important relationships going on here, and we need to study it more." (The work was supported by the National Science Foundation and the U.S. Geological Survey.)

Snowball Earth: New Evidence Hints at Global Glaciation 716.5 Million Years Ago

ScienceDaily

Geologists have found evidence that sea ice extended to the equator 716.5 million years ago, bringing new precision to a "snowball Earth" event long suspected to have taken place around that time.

Led by scientists at Harvard University, the team reports on its work in the journal *Science*. The new findings -- based on an analysis of ancient tropical rocks that are now found in remote northwestern Canada -- bolster the theory that our planet has, at times in the past, been ice-covered at all latitudes.

Figure 1: In this photo from Canada's Yukon Territory, an iron-rich layer of 716.5-million-year-old glacial deposits (maroon in color) is seen atop an older carbonate reef (gray in color) that formed in the tropics.
(Credit: Francis A. Macdonald/Harvard University)

"This is the first time that the Sturtian glaciation has been shown to have occurred at tropical latitudes, providing direct evidence that this particular glaciation was a 'snowball Earth' event," says lead author Francis A. Macdonald, an assistant professor in the Department of Earth and Planetary Sciences at Harvard. "Our data also suggests that the Sturtian glaciation lasted a minimum of 5 million years."

The survival of eukaryotic life throughout this period indicates sunlight and surface water remained available somewhere on the surface of Earth. The earliest animals arose at roughly the same time, following a major proliferation of eukaryotes.

Even in a snowball Earth, Macdonald says, there would be temperature gradients on Earth and it is likely that ice would be dynamic: flowing, thinning, and forming local patches of open water, providing refuge for life.

"The fossil record suggests that all of the major eukaryotic groups, with the possible exception of animals, existed before the Sturtian glaciation," Macdonald says. "The questions that arise from this are: If a snowball Earth existed, how did these eukaryotes survive? Moreover, did the Sturtian snowball Earth stimulate evolution and the origin of animals?"

"From an evolutionary perspective," he adds, "it's not always a bad thing for life on Earth to face severe stress."

The rocks Macdonald and his colleagues analyzed in Canada's Yukon Territory showed glacial deposits and other signs of glaciation, such as striated clasts, ice rafted debris, and deformation of soft sediments. The scientists were able to determine, based on the magnetism and composition of these rocks, that 716.5 million years ago they were located at sea level in the tropics, at about 10 degrees latitude.

"Because of the high albedo of ice, climate modeling has long predicted that if sea ice were ever to develop within 30 degrees latitude of the equator, the whole ocean would rapidly freeze over," Macdonald says. "So our result implies quite strongly that ice would have been found at all latitudes during the Sturtian glaciation."

Scientists don't know exactly what caused this glaciation or what ended it, but Macdonald says its age of 716.5 million years closely matches the age of a large igneous province stretching more than 1,500 kilometers (932 miles) from Alaska to Ellesmere Island in far northeastern Canada. This coincidence could mean the glaciation was either precipitated or terminated by volcanic activity.

Macdonald's co-authors on the *Science* paper are Phoebe A. Cohen, David T. Johnston, and Daniel P. Schrag at Harvard; Mark D. Schmitz and James L. Crowley of Boise State University; Charles F. Roots of the Geological Survey of Canada; David S. Jones of Washington University in St. Louis; Adam C. Maloof of Princeton University; and Justin V. Strauss.

This work was supported by the Polar Continental Shelf Project and the National Science Foundation's Geobiology and Environmental Geochemistry Program.

As usual of late, the editor sincerely thanks John Christian for suggesting more than several of these articles for the newsletter! Please thank him for spotting some of these suggestions!

NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

NCGS FIELD TRIP

Mammoth Rocks and the Geology of the Sonoma Coast

Sunday April 25, 2010

Field Trip Leaders:

Edward Breck Parkman, *Senior State Archaeologist California State Parks*
Rolfe Erickson, *Professor Emeritus, Sonoma State University, Dept. of Geology*

The Mammoth Rocks site, also known as Sunset Rocks, is located within Sonoma Coast State Park, a unit of the California Department of Parks and Recreation. The site, which is located approximately 80 km north of San Francisco, and 2 km south of the mouth of the Russian River, near Goat Rock, occupies a coastal terrace overlooking the Pacific Ocean. The site consists of four loci of rocks that are characterized by highly polished surfaces and separated by about 300 m. Locus 1, the most northern and primary of the loci, consists of numerous boulders associated with a fractured 20 m tall metamorphic blueschist sea stack. Locus 2 is a 30 m tall blueschist seastack. The other two loci are smaller blueschist boulders (4 and 5 m tall). The four loci surround an enigmatic wetland that might conceivably represent a relic animal wallow.

In 2001, a unique polish was discovered on many of the rock surfaces at the Mammoth Rocks site. The polish is found on exposed vertical exposures to a height of 4 m. The distribution of the polish suggests a polishing agent that was selective, rather than arbitrary and/or uniform. The character of the polish resembles what is found on historic bison rubbing rocks on the American Plains and on elephant rubbing rocks in East Africa. It has been proposed, but not yet proven, that the polish found at the Mammoth Rocks site was derived from the grooming behavior of now-extinct Rancholabrean megafauna, especially the Columbian mammoth and ancient bison.

During our visit to the Mammoth Rocks site, the tour leaders will describe the "discovery" of these unusual polished rocks, the scientific methods that have been employed in their study, and what remains to be done to conclusively determine the origin of the polish.

After lunch, Rolfe Erickson will lead us from Wright's Beach campground north along the ocean cliffs a kilometer or so, studying an exceptional group of Franciscan rocks as we go. We will observe a massive, featureless sandstone-matrix olistostrome melange changing into a tectonic melange of sheared sandstone phacoids in a sheared shale matrix. This happens due to the addition of relatively weak shale layers into the stratigraphy and the action of shearing forces along the plate boundary. We will also study several interesting exotic blocks from the melanges, some of which have unusual shapes suggesting an unusual history for Franciscan units. This hike will provide a good introduction / review to the main Franciscan rock types and structures.

************************************Field Trip Logistics************************************

THIS FIELD TRIP WILL BE LIMITED TO 50 PEOPLE. Cost: $25.00

Please carpool as parking is limited. East Bay people may want to carpool at the BART El Cerrito Del Norte lot. We will meet at 9:30AM at the small parking lots along Goat Rock Rd. within 0.3 mile west of Highway1 south of Jenner and the Russian River. To help coordinate carpooling, a list of attendees and maps will be forwarded before the trip. Field trip includes coffee and donuts, a lunch and a guidebook.

Registration

Registration Form for Mammoth Rocks and the Geology of the Sonoma Coast Field Trip

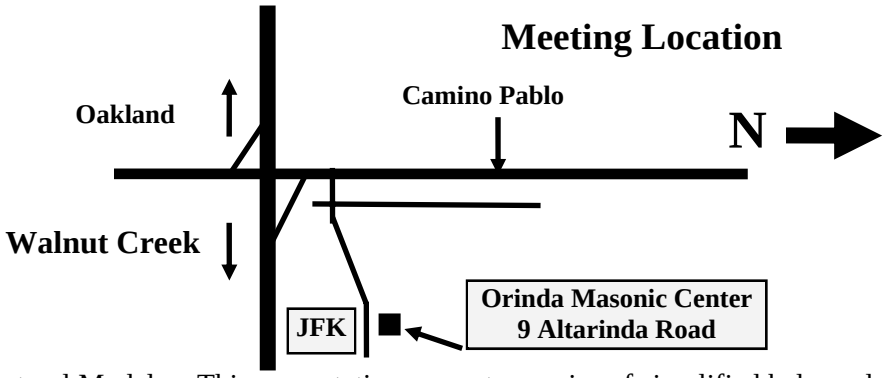
Name:_____ E-mail:_____

Address:_____ Phone (day): _____ Phone (evening):_____

Lunch: Regular:_____ Vegetarian: _____ (Please check one) Check Amount: _____

Please mail a check made out to **NCGS** to: **John Christian,** 931 Liberty St., El Cerrito, CA 94530

Carpooling is strongly suggested for this fieldtrip. Questions: e-mail: jmc62@sbcglobal.net Phone: (510) 558-1585 (evening)



Structural Models – This presentation presents a series of simplified balanced cross sections illustrating a model of Basin and Range tectonic development in time and space. The model suggests that tectonic denudation of thrust culminations begins as an integral part of the topographic rise of the thrust culminations. The primary accommodation of Basin and Range extension was reactivation of the earlier thrust fault ramps. The model is supported in part by the results from three deep exploratory wells drilled by Hunt Oil Company in eastern Nevada and western Utah. The model demonstrates that the key to understanding Basin and Range tectonic development lies in understanding the style and modification of Mesozoic thrusting.

Biography: Dr. M.C. Erskine has more than 55 years of professional experience as an economic geologist and geophysicist, including nine years as President and chief scientist of Eureka Resource Associates, Inc., a consulting firm specializing in resource exploration and exploration research. Clients have included major mining and oil companies, geothermal companies, banks, other financial institutions, and legal firms, including the U.S. Department of Justice. He graduated from the Colorado School of Mines with a degree in Geological Engineeing, received his Masters of Science in 1964, and a Ph.D. in 1970, both from the University of California, Berkeley. Dr. Erskine has published papers, given seminars, and led field trips on topics that include regional tectonics; geophysical and remote sensing interpretations; exploration economics and philosophy. He has developed geological models for the interpretation of remote sensing, geophysical and geochemical data in mineral exploration, hydrocarbon exploration and geothermal exploration.

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Would you like to receive the NCGS newsletter by e-mail? If you are not already doing so, and would like to, please contact **Dan Day** at danday94@pacbell.net to sign up for this free service.